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First Named Inventor	Norihiko Furuta
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Attorney Docket Number	488-00063

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Return receipt postcard
Response with copy of certified translation of priority document

Remarks

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

Firm Or Individual Name	Joseph J. Jochman, Reg. No. 25,058 ANDRUS, SCEALES, STARKE & SAWALL, LLP 100 East Wisconsin Avenue, Suite 1100, Milwaukee, WI 53202
Signature	Joseph J. Jochman
Date	September 27, 2005

CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on this date:

September 27, 2005

Typed or printed name	Barbara A. Johnson		
Signature	Barbara A. Johnson	Date	9/27/05

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application Of:	)
	)
NORIHIKO FURUTA ET AL	)
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Application No.: 10/698,239	)
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Filed: 10/31/2003	)
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Group Art Unit: 3679	)
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Examiner: James M. Hewitt	)
	)
HOSE WITH CORRUGATED METAL TUBE	)

RESPONSE

COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

In response to the e-mail request of Examiner Hewitt on July 27, 2005, enclosed is a certified English translation of priority document JP 2002-319153.

Respectfully submitted,

ANDRUS, SCEALES, STARKE & SAWALL, LLP

Joseph J. Jochman
Reg. No. 25,058

Andrus, Sceales, Starke & Sawall, LLP
100 East Wisconsin Avenue, Suite 1100
Milwaukee, WI 53202
(414) 271-7590
Attorney Docket No: 488-00063

DECLARATION

I, Sakiko Kobori,
do hereby solemnly and sincerely declare:
that I am well acquainted with both of the Japanese language and the English language; and
that the attached document is a true English translation of the priority document of Japanese Patent Application No. 2002-319153 (319153/2002).
And I make this solemn declaration conscientiously believing the same to be true and correct.

On this 22nd day of September

Name: Sakiko Kobori Sakiko Kobori

10-405, 22-3, Yayoidai, Izumi-ku, Yokohama 245-0008, Kanagawa, JAPAN

JAPAN PATENT OFFICE

This is to certify that the annexed is a true copy of the following application as filed with this Office.

Date of Application: October 31, 2002

Application Number: Japanese Patent Application No.2002-319153
[ST.10/C]: [JP2002-319153]

Applicant(s): TOKAI RUBBER INDUSTRIES, LTD.

August 11, 2003
Commissioner,
Japan Patent Office Yasuo Imai

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[Inventor]
[Domicile or Residence] c/o TOKAI RUBBER INDUSTRIES, LTD. , 1, Higashi 3-chome, Komaki-shi, Japan
[Name] Norihiko Furuta
[Applicant]
[Identification Number] 000219602
[Domicile or Residence] 1, Higashi 3-chome, Komaki-shi, Aichi-ken Japan
[Name or Appellation] TOKAI RUBBER INDUSTRIES, LTD.
[Representative] Akira Fujii
[Agent]
[Identification Number] 100089440
[Domicile or Residence] Room 904, Daiichi-Chisan Building, 1-3, Tsubakicho, Nakamura-ku, Nagoya-shi, Aichi-ken
[Patent Attorney]
[Name or Appellation] Kazuo Yoshida
[Telephone No.] 052-451-9300
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[Name of the Document] Specification
[Title of the Invention] HOSE WITH CORRUGATED METAL TUBE
[Scope of Claims]

[Claim 1] A hose with corrugated metal tube comprising a hose body having an inner layer including a corrugated metal tube and outer layer including a reinforced layer and circumscribing a radial outer side of the inner layer, and a socket fitting fitted on the hose body at an axial end portion thereof, and compressed or swaged radially inwardly to be secured thereto;

wherein the corrugated metal tube is provided with a straight-walled portion extending straight in an axial direction or a preformed incomplete corrugated portion on an axial end portion thereof, the straight-walled portion or the incomplete corrugated portion are arranged so as to extend for a distance minimum 10mm from a last compressed or swaged point of the socket fitting, farthest away from an end of the hose body, along a longitudinal direction of the hose, toward a direction away from the end of the hose body.

[Claim 2] The hose with corrugated metal tube as set forth in claim 1 wherein a compressing or swaging rate for the socket fitting at the last compressed or swaged point is minimum 20%.

[Detailed Description of the Invention]

[0001]

[Technical Field to which the Invention Pertains]

The present invention relates to a hose with corrugated metal tube which is suitable for a fuel conveying hose for automobiles, a refrigerant conveying hose or any other fluid conveying hose, and more particularly to a hose with corrugated metal tube including characteristic structure of an axial end portion thereof.

[0002]

[Background of the Invention]

Typical rubber hoses, for example, made of NBR/PVC blend (blended product of acrylonitrile-butadiene rubber and polyvinyl chloride) which is excellent in resistance to gasoline permeability, or the like have been used conventionally for conveying fuel for automobiles or the like in view of their high vibration-absorbability, easy assembling or the like. However, for the purpose of global environment protection, the regulations have been recently tighten against permeation of fuel for automobiles or the like, and are anticipated to be further tighten in the future. Further, on the other hand, hoses are demanded to meet the requirements to convey a highly permeable fluid such as

hydrogen gas used in fuel cells or carbon dioxide refrigerant. Then it is anticipated difficult to satisfy the required performance with hoses made only of organic materials such as rubber or resin.

[0003]

Accordingly, it is currently considered to adapt a hose having a corrugated metal tube for an inner layer as future hose of low fluid permeability because such a hose is expected to have an extremely high fluid impermeability.

[0004]

As for a hose with corrugated metal tube of this type, such hoses as disclosed in the following patent documents, 1, 2 and 3 are known.

In case of these hoses with corrugated metal tube, even if adapted for hydrogen gas used for fuel cells, a corrugated metal tube in or as an inner layer may reduce gas permeation to zero, i.e., completely eliminates permeation of gas.

[0005]

And, Fig. 5 shows a hose with corrugated metal tube of this type which is invented by the inventors of the present invention as a comparison sample. In Fig. 5, numeral reference 200 indicates a hose body. The hose body 200 is formed with a multi-layered construction. The multi-layered construction has an inner layer including a corrugated metal tube 202 of an innermost layer and an outer layer which circumscribe a radial outer side of the innermost layer and includes an inner elastic layer 204, a reinforced layer 206 and an outer elastic layer 208.

[0006]

Numeral reference 210 indicates a socket fitting fitted on an axial end portion of the hose body 200. The socket fitting 210 is compressed or swaged radially inwardly at three axially spaced swaged points P_1, P_2 and P_3 thereof.

And thereby the socket fitting 210 and a connecting pipe 212 are fixedly secured to an axial end portion of the hose body 200 so as to clamp the axial end portion of the hose body 200 therebetween from inner and outer sides thereof.

[0007]

Meanwhile, as shown in Fig. 6, in such a hose with corrugated metal tube, the corrugated metal tube 202 tends to expand or elongate in an axial direction when an internal pressure is exerted thereto.

Therefore, such hose with corrugated metal tube inherently involves a fear that when an internal pressure is exerted thereto repeatedly, the corrugated metal tube 202 overall repeatedly oscillatingly elongates or expands and contracts in a longitudinal direction, and consequently repeated longitudinal deformation thereof causes a fatigue crack in the corrugated metal tube 202 in any portions thereof.

It is predicted that the corrugated metal tube 202 is strongly restrained from moving on a position corresponding to the last swaged point P_3, a stress is likely concentrated in the position, and consequently the corrugated metal tube 202 is likely subject to fatigue crack or break in particular at the position.

[0008]

However the inventors of the present invention actually conducted an impulse test or repeated pressurizing test to exert internal pressure repeatedly to this hose with corrugated metal tube and found the fact that the corrugated metal tube 202 is cracked or broken generally at a certain distance axially away from the last swaged point P_3 of the socket fitting 210. More specifically, the inventors found the fact that the corrugated metal tube 202 is broken about at 7mm axially away from the last swaged point P_3.

[0009]

The reason is estimated that a portion of the hose body 200 inside of the socket fitting 210 is strongly compressed radially inwardly at the last swaged point P_3 by compressing or swaging the socket fitting 210 radially inwardly, and the compressed portion of the hose body 200 is partly extruded or squeezed out rearwardly (toward the right hand in Fig. 5) as shown by an arrow in Fig. 5.

[0010]

The above are described with reference to a hose for conveying hydrogen gas used in a fuel cell as an example. The similar problems are anticipated in common to any hoses. For example, it may be the case that a hose with corrugated metal tube is employed to convey fuel such as gasoline for the purpose to deal with gasoline permeating to an air or for high temperature and high pressure application due to high output power of equipment (namely low permeability property is markedly required). Also, it may be the case that a hose with corrugated metal tube is employed to convey CO_2 as refrigerant (fluid), which is low in amount of particles just like hydrogen and is highly permeable. Further, it may be any other case that a hose with corrugated metal

tube is applied in fields under severe regulations against gas permeation.

[0011]

[Patent Document 1]

JP, A, 2001-182872

[Patent Document 2]

JP, A, 2001-341230

[Patent Document 3]

JP, U, 51-150511

[0012]

[Means for Solving the Problem]

A hose with corrugated metal tube of the present invention is made in order to settle the problems described above.

According to claim 1, a hose with corrugated metal tube comprises a hose body having an inner layer including a corrugated metal tube and outer layer including a reinforced layer and circumscribing a radial outer side of the inner layer, and a socket fitting fitted on the hose body at an axial end portion thereof, and compressed or swaged radially inwardly to be secured thereto. The corrugated metal tube is provided with a straight-walled portion extending straight in an axial direction or a preformed incomplete corrugated portion on an axial end portion thereof. The straight-walled portion or the incomplete corrugated portion is extended, along a longitudinal direction of the hose, toward a direction away from the end of the hose body, by minimum 10mm from a last compressed or swaged point of the socket fitting, farthest away from an end of the hose body.

[0013]

According to claim 2, a compressing or swaging rate of the last swaged point for the socket fitting may be minimum 20% in the hose with corrugated metal tube in claim 1.

[0014]

[Operation and Beneficial Effects of the Invention]

When a hose with corrugated metal tube is repeatedly subject to an internal pressure, a corrugated metal tube is cracked or broken not at the last swaged point of a socket fitting, but generally at a certain distance axially away from the last swaged point thereof. The reason for this has not been confirmed clearly at present, but is estimated as follows.

[0015]

In the hose with corrugated metal tube as comparison sample shown in Fig. 5, a portion of the hose body 200 inside of the socket fitting 210, specifically a portion thereof corresponding to the last swaged point P_3 is strongly compressed radially and is partly extruded or squeezed out rearwardly (toward the right hand in Fig. 5) when the socket fitting 210 is compressed or swaged.

[0016]

At that time, the reinforced layer 206 is loosen or relaxed at a portion behind the last swaged point P_3, i.e. a portion in a side of the extruded or squeezed-out part of the outer layer of the hose body 200.

In other words, if the reinforced layer 206 is initially braided or winded (herein after explained as "braided") with a reinforcing filament member or members at a neutral angle (about 55°), a braid angle (angle of braiding) of the portion on the side of the extruded or squeezed-out part of the outer layer by the swaged socket fitting 210 is changed to be higher than the initial braid angle.

[0017]

Here, the braid angle of a reinforcing filament member or members in the reinforced layer 206 has a following meaning. If a braid angle (braid angle with respect to an axial direction) of a reinforcing filament member or members in the reinforced layer 206 is higher or larger than the neutral angle, the hose including the reinforced layer 206 overall tends to expand or elongate longitudinally and contract in a radial or diametrical direction so as to make the braid angle of the reinforcing filament member or members close to or to be the neutral angle when an internal pressure is exerted thereto, as shown in Fig. 7 (a) (this is based on the hypothesis that a reinforcing filament member itself or reinforcing filament members themselves do not elongate. The same applies hereinafter).

[0018]

On the contrary, as shown in Fig. 7 (c), if the braid angle of the reinforcing filament member or members in the reinforced layer 206 is lower or smaller than the neutral angle, the hose including the reinforced layer 206 overall tends to contract in a longitudinal direction, expand and deform in a radial direction so as to make the braid angle thereof close to or to be the neutral angle when an internal pressure is exerted thereto.

And, as shown in Fig. 7 (b), if the braid angle of the reinforcing filament member or members in the reinforced layer 206 is initially the neutral angle, the reinforcing filament member or members tend to remain at the initial neutral angle when an internal pressure is exerted thereto. That is, the hose overall tends to remain as it is both in diameter and length.

[0019]

Hence, it is estimated that as the reinforced layer 206 provides small resistance to axial elongation and deformation of the corrugated metal tube 202 in the portion behind the last swaged point P_3 if the braid angle of the reinforcing filament member or members in the reinforced layer 206 becomes high in the portion therebehind as stated above by compressing or swaging the socket fitting 210 radially inwardly, the corrugated metal tube 202 more likely expands or elongates and contracts axially in the portion therebehind.

[0020]

Then the inventors investigated a state of the hose with corrugated metal tube after the repeated pressurizing test conducted thereto, and confirmed the reinforced layer 206 actually loosened or relaxed (surged) at the portion behind the last swaged point P_3.

[0021]

Further, as shown in Fig. 8, the inventors found at the same time that the corrugated portion 202 is flattened, elongated and deformed axially, thereby formed actually into incomplete corrugated portion 214 at a portion behind or rearwardly from the last swaged point P_3 under compressing or swaging pressure of the socket fitting 210, and the corrugated metal tube 202 is cracked or broken at a border region between the incomplete corrugated portion 214 and the complete corrugated portion, specifically at

a distance corresponding to about two hills from the incomplete corrugated portion 214.

[0022]

This phenomenon is estimated to be caused as follows. The incomplete corrugated portion 214, which was already elongated and deformed axially provides high resistance against elongating and contracting deformation in an axial direction when internal pressure is exerted repeatedly. On the other hand, under repeated internal pressure, the complete corrugated portion likely elongates, contracts and deforms in an axial direction, further, as stated above the reinforced layer 206 provides low resistance against elongating deformation in an axial direction of the corrugated metal tube 202 at the position behind the last swaged point P_3, and thereby the corrugated metal tube 202 tends to elongate, contract and deform at the position therebehind. Accordingly a stress is likely concentrated around the border region between the incomplete corrugated portion 214 and the complete corrugated portion specifically. Those factors cooperate each other, and thereby the corrugated metal tube 202 is cracked or broken generally at a certain distance behind the last swaged point P_3.

[0023]

And impulse tests or repeated pressurizing tests are conducted on various hoses with corrugated metal tube, and it is proved that in most of the hoses with corrugated metal tube, corrugated metal tubes are cracked or broken at corrugation hills generally of a certain distance behind the last swaged point P_3 or corrugation hills front or rear of a position of the certain distance behind the last swaged point P_3, specifically about at 7mm therebehind.

[0024]

Here, the incomplete corrugated portion mean corrugated portion in which a pitch between corrugation hills or between corrugation valleys is larger compared to a typical corrugated portion (complete corrugated portion) (for example, the pitch therebetween is 2.0mm or longer in the incomplete corrugated portion, while that is 1.5mm in the complete corrugated portion)(or a difference between a peak and a valley of a corrugation is smaller compared to the complete corrugated portion (for example, the difference is 1.0mm or lower in the incomplete corrugated portion, while that is 1.5mm in the complete corrugated portion)).

[0025]

The present invention is made based on that knowledge. A corrugated metal tube

may be provided with an axially straight tubular or axially straight-walled portion on an axial end portion thereof so as to extend at least for minimum 10mm axially from a last swaged point of a socket fitting.

[0026]

As a corrugated metal tube is provided with a straight-walled portion on one axial end portion thereof so as to extend axially beyond a position of about 7mm behind a last swaged point where the corrugated metal tube is likely cracked or broken, the corrugated metal tube is favorably prevented from fatigue crack or break caused by an action of repeated internal pressures, and thereby service life of a hose having the corrugated metal tube may be effectively prolonged.

[0027]

According to the present invention, instead of extending the straight-walled portion for a predetermined length behind or rearwardly from the last swaged point, a corrugated metal tube may be provided with pre-formed incomplete corrugated portion so as to extend at least for minimum 10mm axially beyond a last swaged point. In this case, the corrugated metal tube is also favorably restrained from fatigue crack or break and thereby service life of a hose having the corrugated metal tube may be also prolonged.

[0028]

It is confirmed that the above phenomenon is likely caused specifically when a swaging rate is minimum 20% at the last swaged point P_3. Therefore, the present invention proves more effective when the swaging rate is minimum 20% at the last swaged point P_3 (claim 2).

[0029]

The swaging rate is given by the following formula.

[Formula 1]

Swaging rate $\square(T_0\square T_1)\square T_0\times 100$ (%)•••(Formula)

where

T_0: Wall thickness of a hose body before swaged

T_1: Wall thickness of a swaged point of the hose body after swaged

[0030]

[Preferred Embodiments]

Now, the preferred embodiments of the present invention will be described in detail with reference to the drawings.

In Figs. 1 and 2, numeral reference 10 indicates a hose with corrugated metal tube (hereinafter referred to as a hose) which is preferably adapted for a hydrogen or hydrogen gas conveying hose, a refrigerant conveying hose for air conditioners, an automobile fuel conveying hose or the like. Numeral reference 12 indicates a hose body, numeral reference 14 a metal connecting pipe fixed to the hose body 12, and numeral reference 16 a metallic socket fitting fitted onto or on an outer surface of the hose body 12 on an axial end portion thereof.

[0031]

The socket fitting 16 is securely compressed or swaged radially inwardly to the hose body 12 and thereby the connecting pipe 14 is, along with the socket fitting 16, fixedly secured to an axial end portion of the hose body 12 so as to clamp the axial end portion thereof from a radial inside and a radial outside thereof.

[0032]

The socket fitting 16 is securely compressed or swaged radially inwardly to the hose body 12 on three axially spaced swaged points thereof. In Fig. 2, P_1 indicates a first swaged point nearest an axial end of the hose body 12, P_2 a second swaged point and P_3 a third swaged point (last swaged portion).

[0033]

As shown in Fig. 2, the socket fitting 16 has a radially inwardly directed collar-like portion 18 on an axial end thereof.

On the other hand, the connecting pipe 14 is formed with a fit-engagement groove 20 at a position axially corresponding to the collar-like portion 18 on a radially outer surface thereof. An inner end portion of the collar-like portion 18 is fitted in and engaged with the fit-engagement groove 20 by securely compressing or swaging the socket fitting 16 radially inwardly to the hose body 12.

[0034]

As shown in Fig. 2, the hose body 12 includes a corrugated metal tube 22 as an innermost layer. An inner elastic layer 24, a reinforced layer 26 and an outer elastic layer 28 are laminated on a radially outer side of the corrugated metal tube 22, and fixedly bonded in a unitary relation to an adjacent layer by vulcanizing or other manner.

In this embodiment, the inner elastic layer 24, the reinforced layer 26 and the outer elastic layer 28 construct outer layer circumscribing the corrugated metal tube 22.

[0035]

And, in this embodiment, the reinforced layer 26 is constructed by braiding reinforcing filament members at a pre-determined braid angle in an opposed angled relation with one another.

The reinforced layer 26 may be a fiber-reinforced layer or a wire -reinforced layer.

And the inner elastic layer 24 and the outer elastic layer 28 may be made of elastic material such as rubber.

[0036]

On the other hand, the corrugated metal tube 22 as an innermost layer is formed with a corrugated portion 30 for generally entire axial length thereof, which provides the corrugated metal tube 22 with flexibility.

That is, although, in this embodiment, an innermost layer of the hose 10 is constructed by a metal tube, the hose 10 is provided entirely with flexibility, thanks to the corrugated portion 30 formed on the metal tube.

[0037]

The corrugated metal tube 22 may be made of materials such as steel products (including stainless steel), copper, copper alloy, aluminum, aluminum alloy, nickel, nickel alloy, titanium or titanium alloy, and preferably may be made of stainless steel.

[0038]

A wall thickness of the corrugated metal tube 22 may be from 20 to 500 μm,

preferably is minimum 50μm in view of preventing defects such as pinholes and further in view of processing of the corrugated portion 30 or the like, and maximum 300μm in view of flexibility and durability.

[0039]

The corrugated metal tube 22 has a straight-walled portion (straight tubular portion) 32 extending straight in an axial direction on an axial end portion thereof.

The straight-walled portion 32 is configured as an extending portion 34 on a leading end side, which extends outwardly in an axial direction and is exposed out of the outer layer comprising the inner elastic layer 24, the reinforced layer 26 and the outer elastic layer 28.

[0040]

And, a portion of the extending portion 34 is clamped radially with an inner end portion of the collar-like portion 18 and the fit-engagement groove 20 of the connecting pipe 14 by securely compressing or swaging the socket fitting 16. The corrugated metal tube 22 is firmly fixed to the connecting pipe 14 at the portion, while an air tight seal is provided between the corrugated metal tube 22 and an outer surface of the connecting pipe 14.

[0041]

However, securing structure between an axial end portion of the corrugated metal tube 22 and the connecting pipe 14 as stated is only one of embodiments. According to a shape of a connecting pipe 14 or other factors, the axial end portion of the corrugated metal tube 22 may be securely fixed to a connecting pipe 14 of various shape, or may be sealed with respect to the connecting pipe 14 of various shape in various securing structure or sealing structure.

[0042]

In this embodiment, the connecting pipe 14 and the straight-walled portion 32 of the corrugated metal tube 22 are arranged respectively so as to extend for a distance L (L=15mm in this embodiment) longitudinally toward the right-hand side in Fig. 2 beyond the third or last swaged point P_3 of the socket fitting 16, namely in a direction away from an axial end of the hose body 12.

And, in this embodiment, the socket fitting 16 is arranged so as to extend further

beyond right-hand ends of the connecting pipe 14 and the straight-walled portion 32 in Fig. 2, for a distance Q

[0043]

In the hose 10 of this embodiment as stated above, the corrugated metal tube 22 is formed with the straight-walled portion 32 on an axial end portion thereof which is arranged so as to extend for a distance L beyond the third or last swaged point P_3. That means, the straight-walled portion 32 extends axially long beyond a position of about 7mm behind the third swaged point P_3 where the corrugated metal tube 22 is likely cracked or broken, thereby the corrugated metal tube 22 may be favorably prevented from fatigue crack caused by an action of repeated internal pressures, and service life of the hose 10 may be effectively prolonged.

[0044]

By the way, Table 1 shows results of Impulse Test or repeatedly pressurizing test conducted on an example according to this embodiment and a comparative example. In Table 1, for example, as for the example of the embodiment, the row No. 1 where a number of cycle repetitions is 31,000 times and a cracking point is 17mm means that the corrugated metal tube 22 is cracked or broken at 17mm behind the swaged point P_3 when pressure is repeatedly exerted thereto 31,000 times.

[0045]

[Table 1]

Table 1 – Results of Impulse Test

No.	Example		Comparative Example	
	Cycle Repetitions (10,000 times)	Cracking Point (mm)	Cycle Repetitions (10,000 times)	Cracking Point (mm)
1	3.1	17	1.2	7
2	3.3	17	1.3	7
3	3.8	15.5	1.2	7
4	2.5	18.5	0.9	5.5
5	4.0	17	1.5	7
6	5.1	17	1.8	8.5

7	2.8	18.5	1.2	8.5
8	4.0	17	1.1	7
9	3.3	15.5	1.5	7
10	4.2	17	0.7	7

[0046]

In the example, as shown in Fig. 4 (A), the first swaged point P_1 is arranged at a distance 8mm from an inner surface of the collar-like portion 18, the second swaged point P_2 at a distance 10mm from the first swaged point P_1, and the third swaged point P_3 at a distance 10mm from the second swaged point P_2.

The straight-walled portion 32 and the connecting pipe 14 are arranged so as to extend for a distance 15mm beyond the last or third swaged point P_3 in a right-hand direction in Fig.4 (A).

[0047]

And, the corrugated metal tube 22 is made of stainless steel in thickness of 0.15mm. The inner elastic layer 24 is made of EPDM in wall-thickness of 0.5mm, while the outer elastic layer 28 is made also of EPDM in wall-thickness of 1.0mm.

The reinforced layer 26 is constructed by braiding a reinforcing filament member or members (reinforcing threads), more specifically aramid type filament members or yarns of 1,500 D (deniers) in thickness at braid angle 55°.

The corrugated portion 30 of the corrugated metal tube 22 is formed of an inner diameter of 6mm and an outer diameter of 9mm.

[0048]

A swaging rate of the socket fitting 16 on the first swaged point P_1 is 30%, that on the second swaged point P_2 is 30%, and that on the third swaged point P_3 is 20%.

[0049]

This comparative example as shown in Fig. 4 (B) has basically similar configuration in each portion to the example of Fig. 4 (A). However, in the comparative example, right-hand ends in Fig. 4 (B) of the connecting pipe 212 and the straight-walled portion of the corrugated metal tube 202 are arranged at a position axially corresponding to the last or third swaged point P_3.

And an axial end (right-hand end in Fig. 4 (B)) of the socket fitting 210 is located at a distance 4.0mm from the third swaged point P_3.

[0050]

The impulse test is performed under conditions generally according to JASO (Japanese Automobile Standards Organization) M321.

However, test pressures 0 <--> 10Mpa are applied in this test, although test pressures 0 <--> 3.53Mpa are specified in JASO M321.

[0051]

As seen from the results of Table 1, cracking points on the corrugated metal tubes 22, 202 differ between the example and the comparative example. And, thereby the example has a longer duration life.

[0052]

As stated, the corrugated metal tube 22 of the example of the embodiment is broken at points different from those of the corrugated metal tube 202 of the comparative example, and the example of the embodiment has longer duration life than the comparative example. In the example of the embodiment, the straight-walled portion 32 on an axial end portion of the corrugated metal tube 22 extends axially long beyond possible breaking points in the comparative example as stated above, and there is no or little loosen or irregular portion by swaging in the reinforced layer 26 at an axial position adjacent to the straight-walled portion 32. It is estimated that these factors cooperate each other to realize a long duration life of the example.

[0053]

Table 2 shows elongation found out relative to the hose body 12 of an example of the embodiment at distance varied by 5mm from the third or last swaged point P_3, when the socket fitting 16 is compressed or swaged radially inwardly to the hose body 12 at various swaging rates.

Here, elongation is given in values when an internal pressure of 10MPa is exerted to the hose body 12.

In Table 2, "Main Part of the Hose" means a portion of the hose body 12 15mm or over from the swaged portion P_3.

[0054]

[Table 2]

Table 2

		Swaging Rate (%)		
Swaged Point	P_1	30	30	30

		P_2	30	30	30
		P_3	30	20	10
Elongation under Pressure 10Mpa (mm)	Distance from the Swaged Point P_3	0 to 5mm	0.8	0.6	0.4
		5 to 10mm	0.5	0.4	0.3
		10 to 15mm	0.3	0.2	0.2
	Main Part of the Hose (15mm or over)		0.13	0.13	0.13

[0055] Table 2 shows a conclusion that the hose body 12 of this embodiment elongates largely or at high rate in the range of 10mm from the third swaged point P_3 while elongates a little or at low rate beyond that range. Elongation of the hose body 12 varies depending on the swaging rate at the third swaged point P_3, and the hose body 12 elongates a little or at low rate in case that the swaging rate is under 20% at the third swaged point P_3.

In other words, it shows a conclusion that the reinforced layer 26 tends to be loosen largely or at high rate in the range of 10mm from the third swaged point P_3, and a loosening degree varies depending on a swaging rate.

[0056]

The above is only one embodiment of the hose with corrugated metal tube of the present invention. According to the present invention, a hose with corrugated metal tube may be constructed in variety of modes.

In another embodiment of the present invention shown in Fig. 3 (A), a straight-walled portion 32 of a corrugated metal tube 22 is arranged so as to extend further rearwardly (right-hand side in Fig. 3 (A)) compared to that of the first embodiment (shown in Fig. 2), namely so as to extend for a distance L_1 ($L_1 > L$) behind or rearwardly from a third swaged point P_3.

[0057]

In yet another embodiment of the present invention shown in Fig. 3 (B), only a straight-walled portion 32 is arranged so as to extend for a distance L behind or rearwardly from a third swaged point P_3, while a connecting pipe 14 is formed so that a rear end (right-hand end in Fig.3 (B)) thereof extends to a position axially corresponding to the third swaged point P_3.

[0058]

According to the present invention, a swaged point swaged at a swaging rate of minimum 20% and located farthest from an end of a hose body 12 may be determined as a last swaged point and a hose 10 may be constructed by arranging a straight-walled portion 32 so as to extend for minimum 10mm from this last swaged point.

Fig. 3 (C) shows thus constructed hose 10 as further another embodiment.

[0059]

In the further another embodiment, a socket fitting 16 is compressed or swaged radially inwardly to the hose body 12 also at a forth swaged point P_4 further behind or rearwardly from the third swaged point P_3 in a hose of a type of the first embodiment.

However, the swaging rate at the forth swaged point P_4 is under 20% (while the swaging rate at swaged points P_1, P_2, P_3 is minimum 20% in the first to forth embodiments (Figs. 2 and 3)). In the further another embodiment, the straight-walled portion 32 of the corrugated metal tube 22 extends for a distance L (L is minimum 10mm) from the third swaged point P_3 and terminates ahead of the forth swaged point P_4.

[0060]

In the above embodiments, the straight-walled portion 32 is arranged so as to extend relatively long. However, in the present invention, instead of the straight-walled portion 32, pre-formed incomplete corrugated portion may be arranged so as to extend at least for minimum 10mm beyond the third swaged point P_3 in an axial direction. Even in this configuration, also the corrugated metal tube 22 may be favorably prevented from fatigue crack and the duration and service life of the hose 10 may be prolonged.

[0061]

Although the present invention has been described in terms of preferred embodiments, these are only some of the preferred embodiments. It will be understood that a variety of modifications can be made without departing from the scope of the invention.

[Brief Description of the Drawings]

[Fig. 1] Fig. 1 is a view of a hose with corrugated metal tube as one embodiment according to the present invention.

[Fig. 2] Fig. 2 is a longitudinal-sectional view of a relevant portion of the

hose with corrugated metal tube as the one embodiment.

[Fig. 3] Fig. 3 is a longitudinal-sectional view of a relevant portion of each of other embodiments than the one embodiment according to the present invention.

[Fig. 4] Fig. 4 is a view to explain concretely an example and a comparative example that are used for confirmation of effects.

[Fig. 5] Fig. 5 is a view of a hose with corrugated metal tube that is devised by the inventors to be contrasted with the present invention.

[Fig. 6] Fig. 6 is an explanatory view showing expanding and contracting of a corrugated metal tube.

[Fig. 7] Fig.7 is an explanatory view showing a relationship between a braid or winding angle of a reinforced layer and expanding/contracting of the reinforced layer.

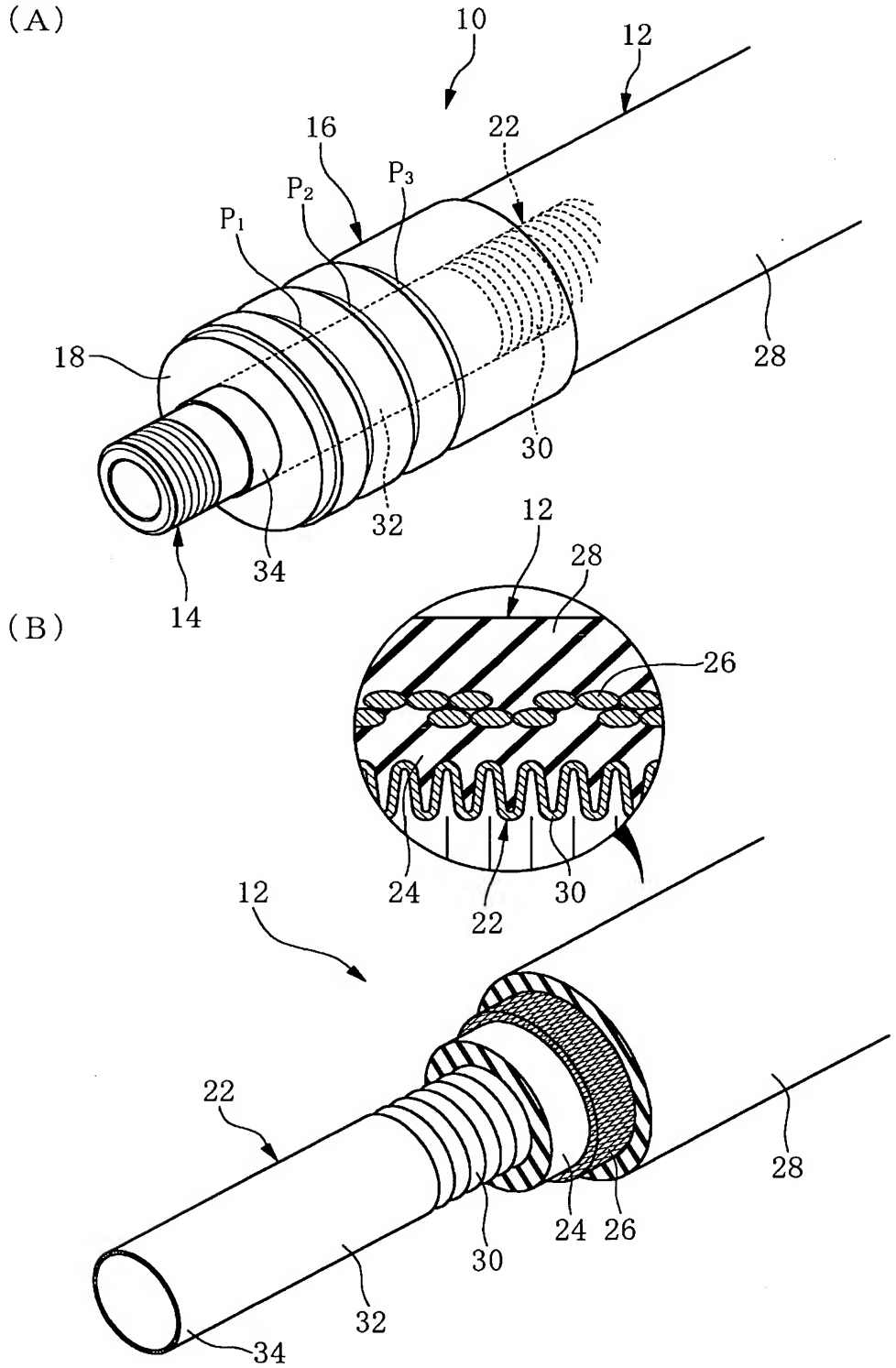
[Fig. 8] Fig. 8 is a view to explain a defect caused in the hose with corrugated metal tube of a type in Fig. 5.

[Explanations of Reference Numerals]

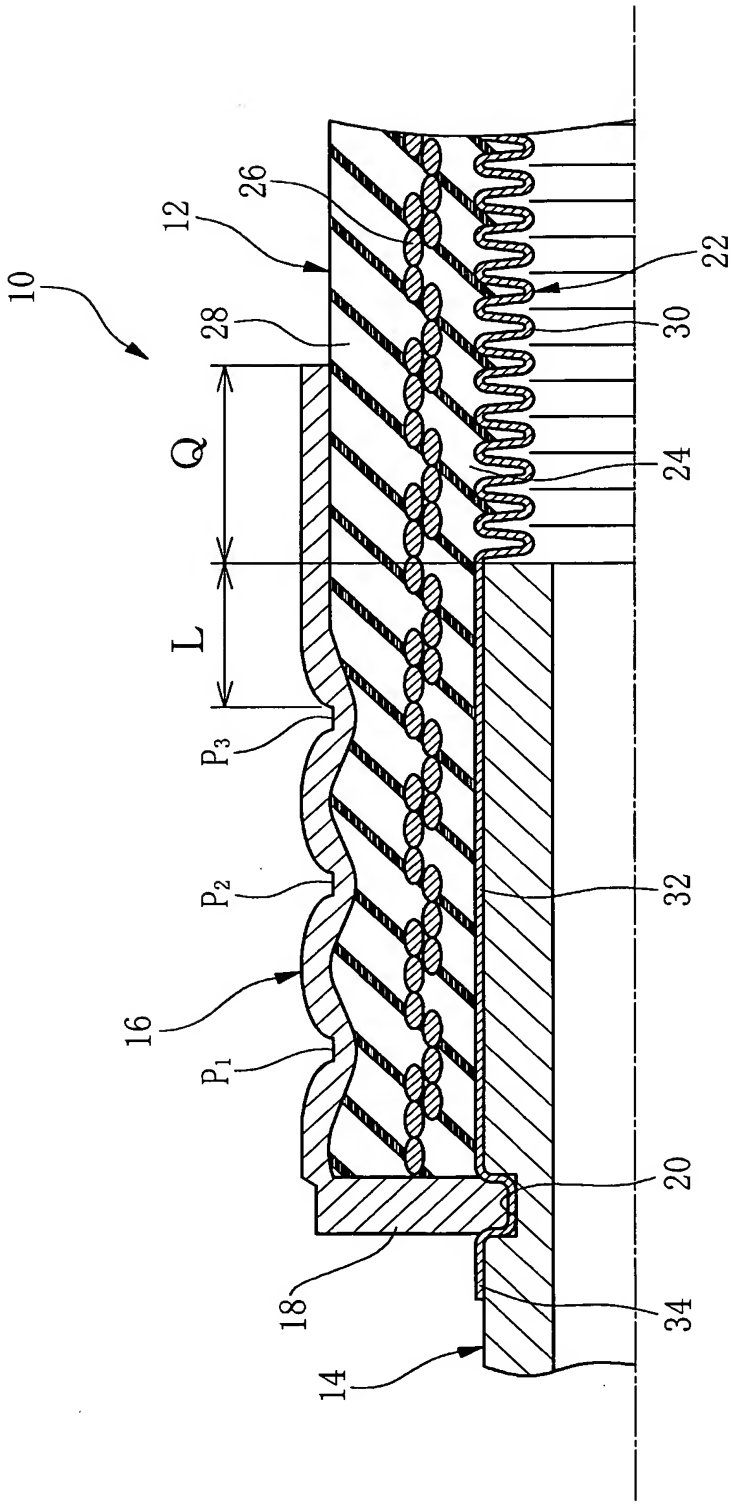
10	Hose with corrugated metal tube
12	Hose body
16	Socket fitting
22	Corrugated metal tube
24	Inner elastic layer
26	Reinforced layer
28	Outer elastic layer
32	Straight-walled portion
P_3	Third swaged portion (last swaged portion)
L , L_1	Distance

[Name of Document] Drawing

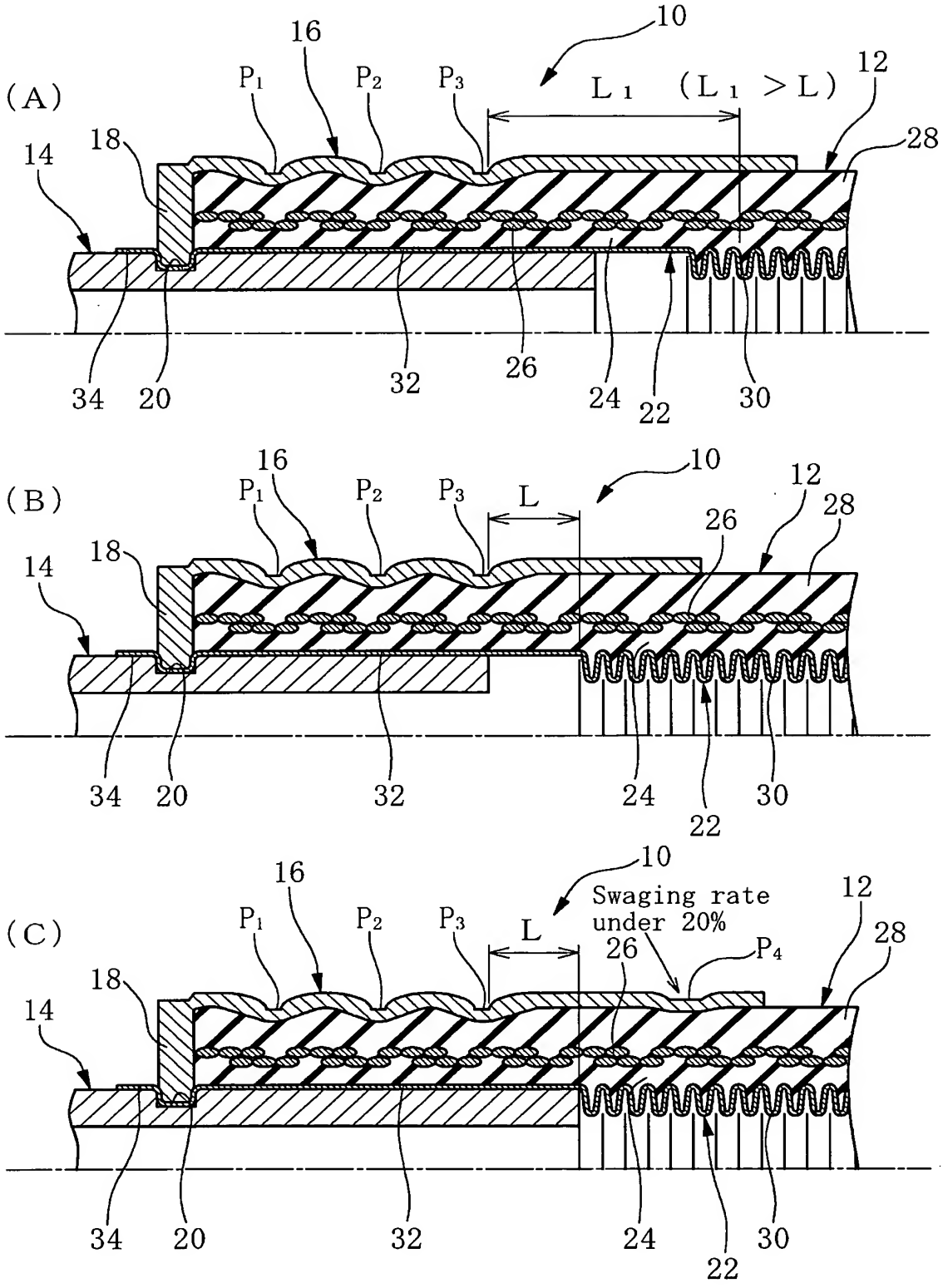
[FIG.1]



[FIG.2]

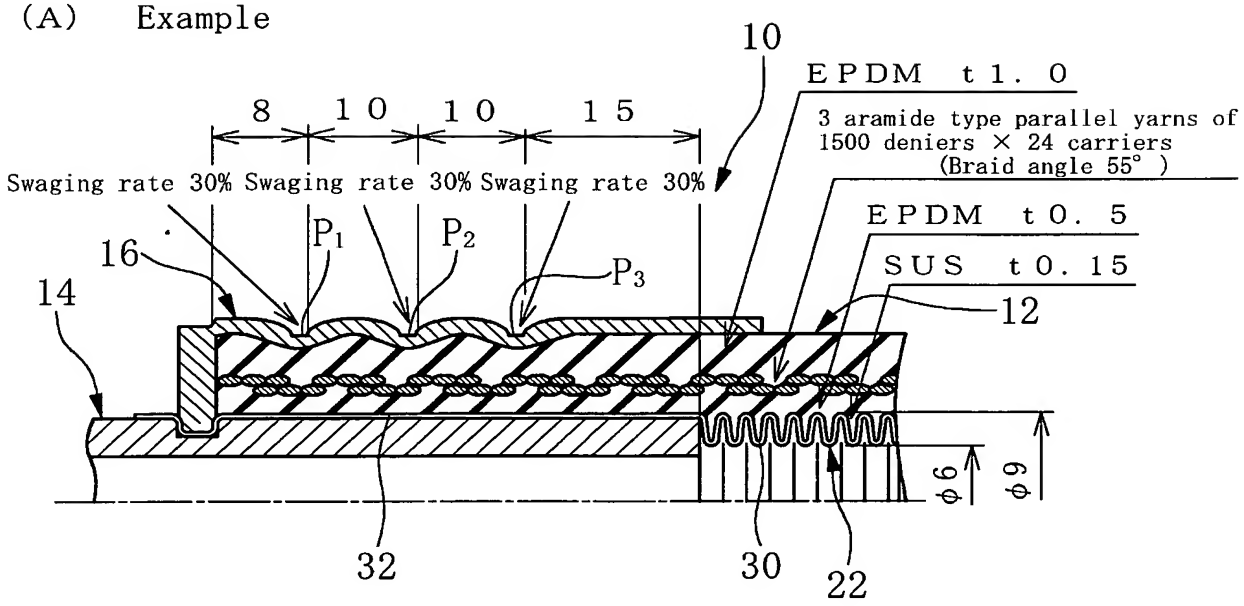


[FIG.3]

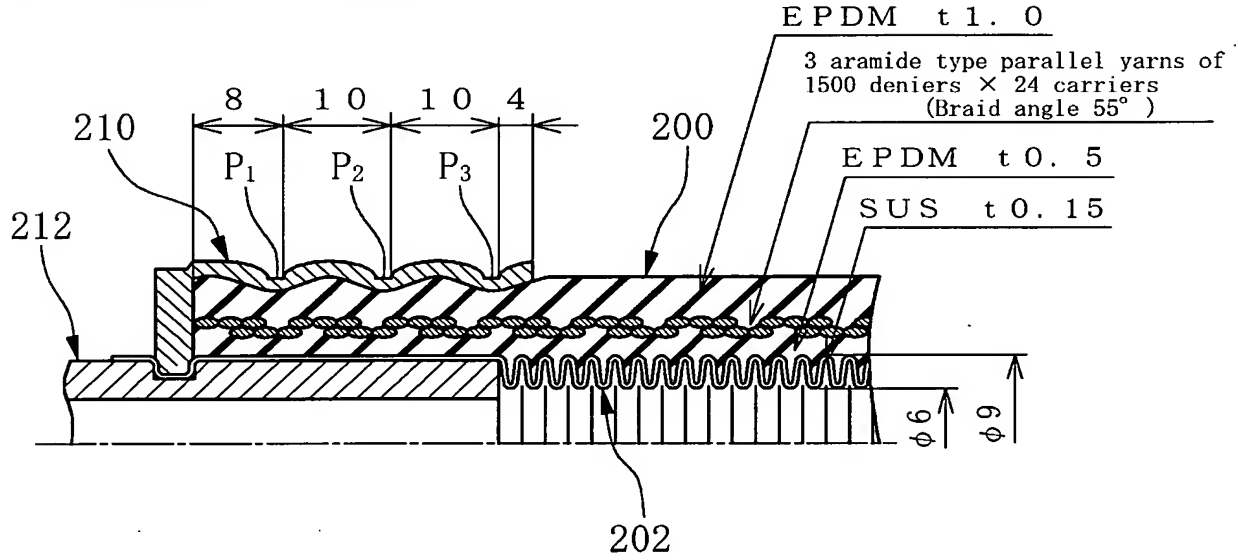

(A)
10
16
P1
P2
P3
L1 (L1 > L)
12
28
14
18
34
20
32
26
24
22
30
(B)
10
16
P1
P2
P3
L
12
28
26
14
18
34
20
32
24
22
30
(C)
10
16
P1
P2
P3
L
Swaging rate
under 20%
26
P4
12
28
14
18
34
20
32
24
22
30

[FIG.4]

(A) Example



(B) Comparative example

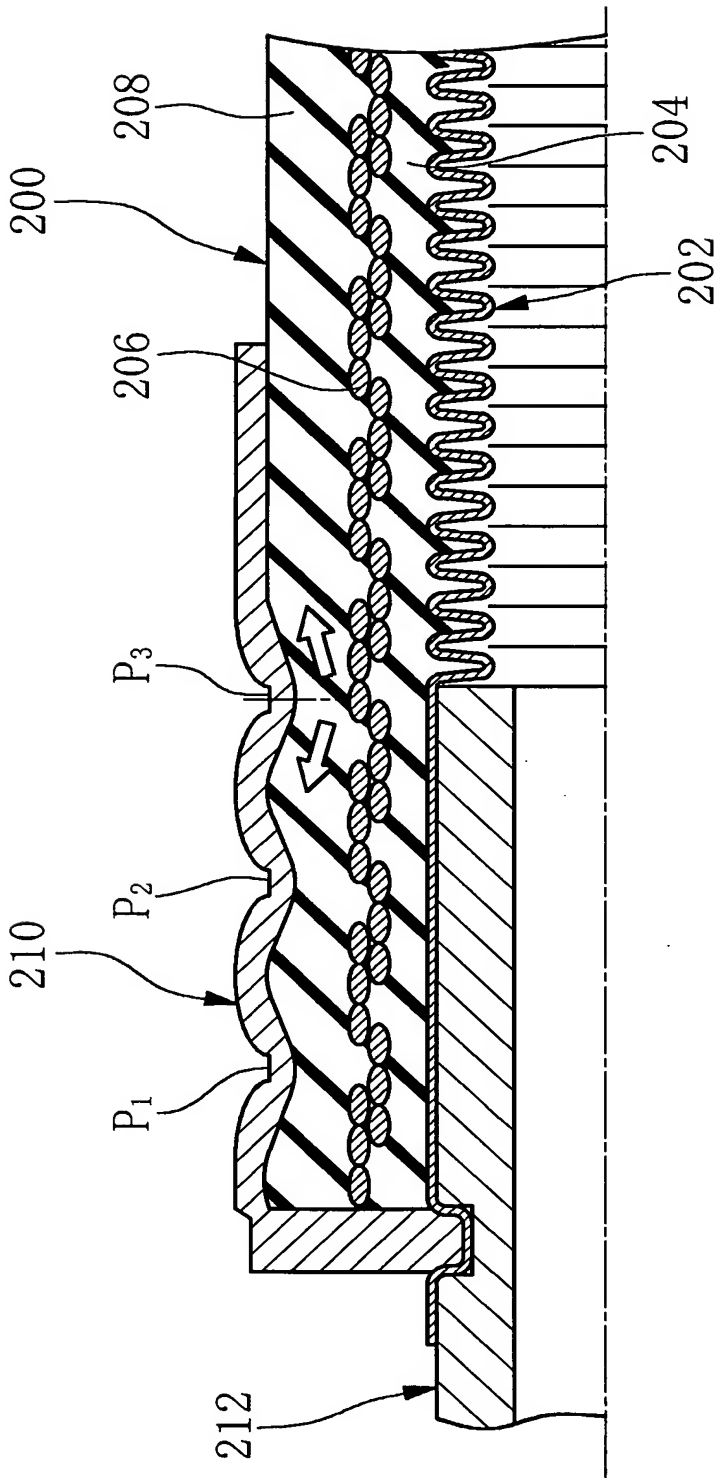


$$\text{Swaging rate} = \frac{T_0 - T_1}{T_0} \times 100\ (\%)$$

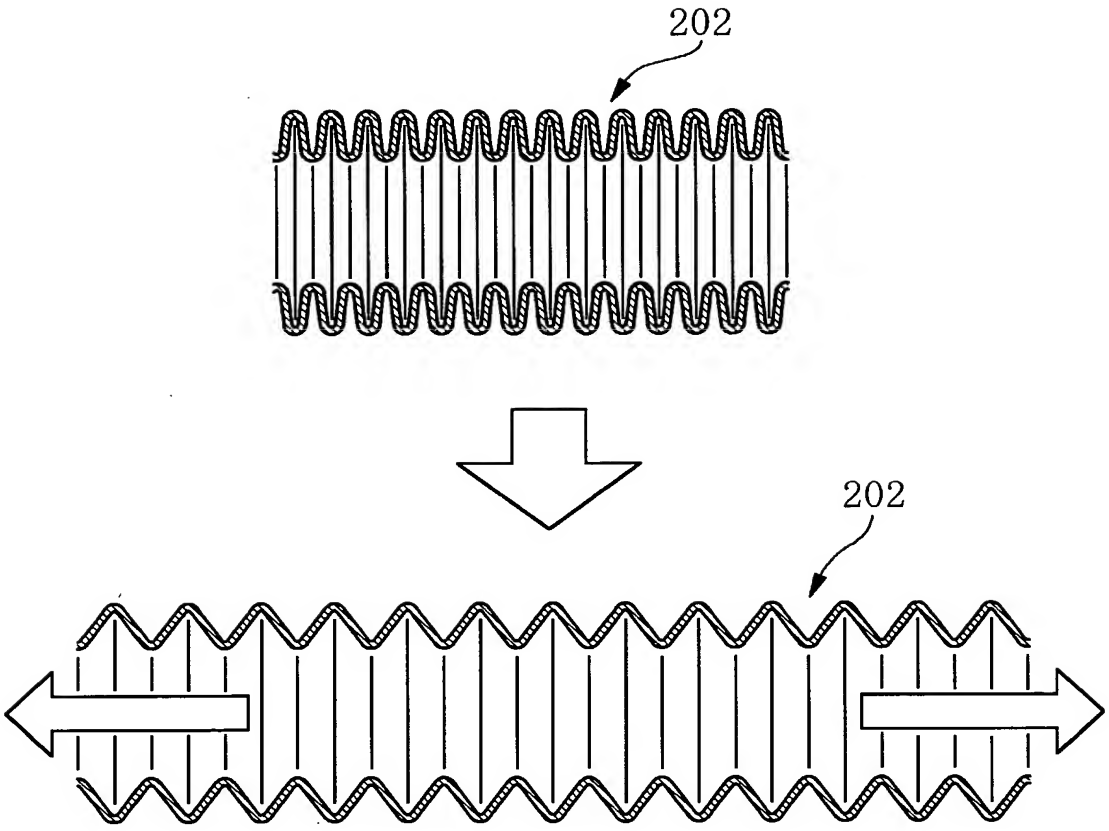
T_0 : Wall thickness of a hose body before swaged

T_1 : Wall thickness of a swaged point of the hose body after swaged

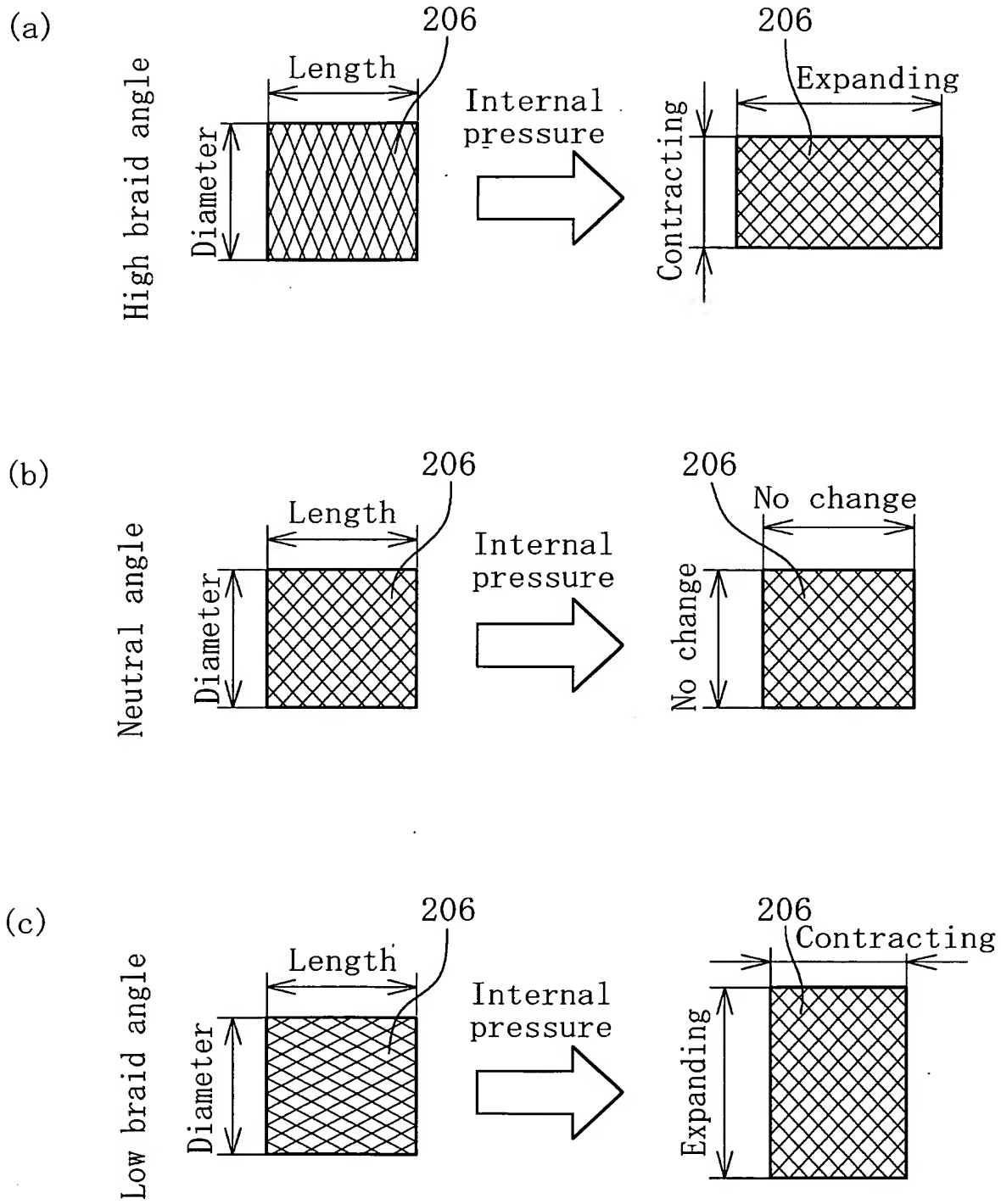
[FIG.5]



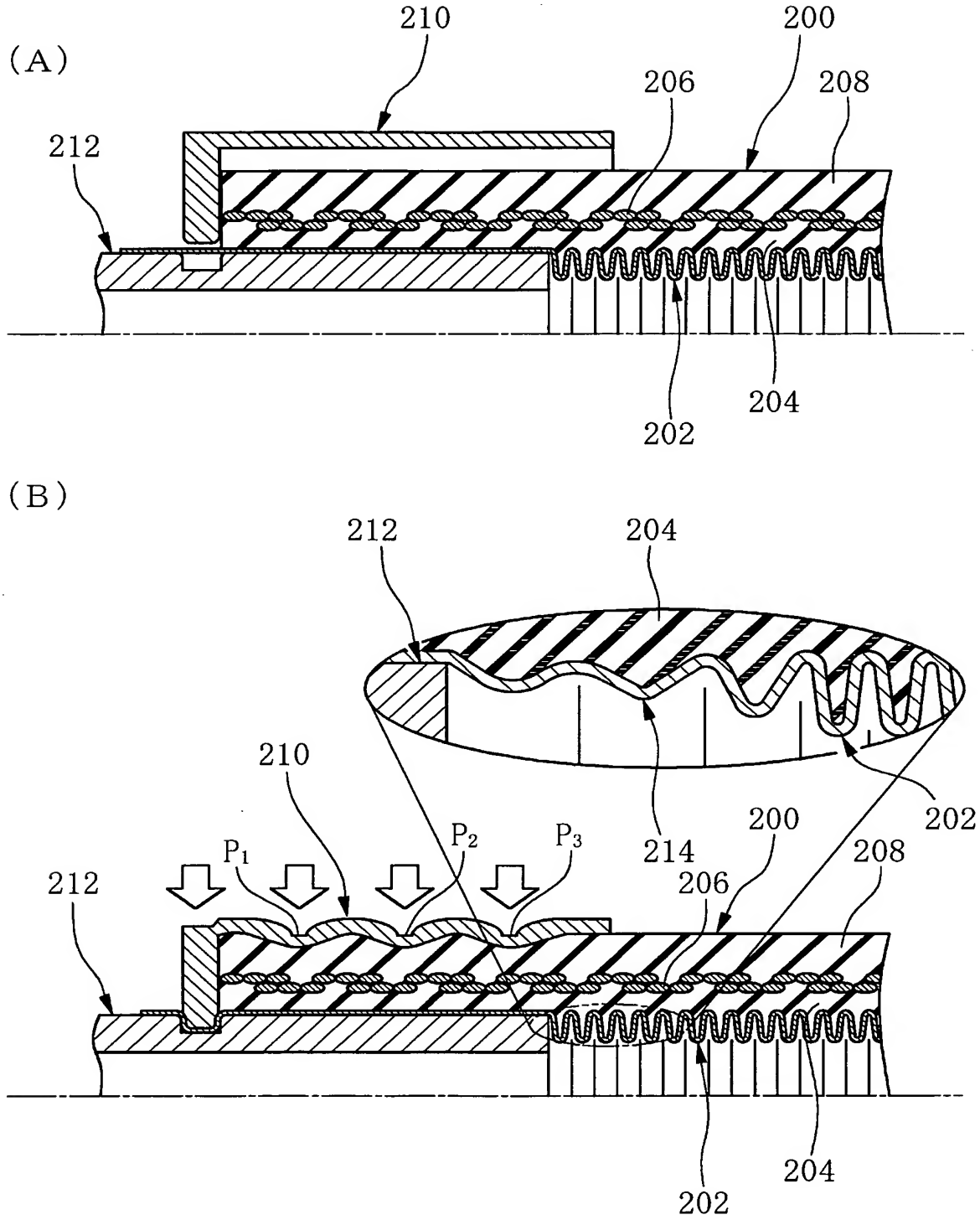
[FIG.6]



[FIG.7]


(a)
High braid angle
206
Length
Diameter
Internal pressure
206
Expanding
Contracting
(b)
Neutral angle
206
Length
Diameter
Internal pressure
206
No change
No change
(c)
Low braid angle
206
Length
Diameter
Internal pressure
206
Contracting
Expanding

[FIG.8]


(A)
210
200
206
208
212
202
204
(B)
212
204
210
202
214
200
208
P_1
P_2
P_3
206
212
204
202

[Name of the Document] ABSTRACT

[Abstract]

[Problem to be Solved]

With regard to a hose with corrugated metal tub having an inner layer including a corrugated metal tube and a socket fitting swaged to an outer surface of an axial end portion of a hose body, it is an object to restrain the corrugated metal tube from fatigue crack on an axial end portion thereof under an action of repeated inner pressure.

[Means to Solve the Problem]

A hose with corrugated metal tube 10 comprises a hose body 12 having an inner layer including a corrugated metal tube 22, and a socket fitting 16 fitted on the hose body 12 at an axial end portion thereof and compressed or swaged radially inwardly to be secured thereto. The hose body 12 comprises an inner elastic layer 24, a reinforced layer 26 and an outer elastic layer 28 circumscribing a radial outer side of the inner layer. The corrugated metal tube 22 is provided with an axially straight-walled portion 32 so as to extend for minimum 10mm from a third swaged point P_3 on which the socket fitting 16 is swaged last.

[Representative Drawing] Fig. 2